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[C. Weis NOTES: 1) Label all X and Y axes on graphs. Many vertical axes are without labels.
2) All tables and graphs should have the number of participants (N) clearly indicated.
3) Distinguish between "popping" vermiculite at home vs. "popping" at the exfoliation plant
4) With only 2.6% showing no exposure to asbestos the backgound rate is likely to be elevated. A more detailed discussion of the influence of elevated background on the outcome of the investigation is warranted.
5) Please acknowledge the role this study will have on ongoing and future EPA investigations. Several suggestions are included in my marks.
6) Please acknowledge Paul Peronard, OSC who funded 4.7 million of this investigation, built and purchased the radiological facilities and 2 clinics used to effect the study, and is still paying the rent.]

~~Report to the Community~~
~~of the~~
Year 2000
Medical Testing of Individuals Potentially Exposed To Asbestoform Minerals Associated with Vermiculite in Libby, Montana:

A Report to the Community

Separate Non occ. / non occ contact?

Draft in Preparation - August 17, 2001

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CONTENTS

INTRODUCTION . . . .

BACKGROUND OF PROJECT . . . .

METHODS . . . .

Participants . . . .

Exposure Characterization . . . .

RESULTS . . . .

CONCLUSIONS . . . .

SUMMARY

REFERENCES

Appendix I

INTRODUCTION

A community-based medical testing program was developed to respond to reports of illness among persons exposed to asbestos-contaminated vermiculite in Libby, Montana. This medical testing program, a part of the Libby Community Environmental Health Project, was undertaken by the Agency for Toxic Substances and Disease Registry (ATSDR), an agency of the U.S. Department of Health and Human Services (DHHS), with the cooperation of the DHHS Region VIII Office, the U.S. Environmental Protection Agency (EPA), the Montana Department of Health and Human Services, and the Lincoln County Environmental Health Department.

The principal goal of the medical testing program is to identify the asbestos-related health effects of participants exposed to asbestos from the vermiculite mine near Libby, Montana, and to refer these individuals for additional medical evaluation as needed.

The program was not designed as an analytic epidemiologic study with comparison groups and random sampling of exposed and comparison groups. Nevertheless, the data collected provides important information about the prevalence and degree of asbestos-related abnormalities among a large number of current and former Libby residents, and about the possible relationships between these abnormalities and a number of exposure pathways reported by community members. The main objectives of the data analysis were (1) to identify and quantify possible asbestos-related health outcomes among participants and (2) to examine any association between these outcomes and the particpants' exposure histories. Other important goals of the program are to

(a) provide EPA with information needed to identify and eliminate current exposures to asbestos in the community, [THIS SECTION IS IMPORTANT FOR YOUR COST RECOVERY-PLEASE DON'T REMOVE]

(b) identify the types of illnesses experienced by these exposed people in order to better inform local physicians, and

(c) provide the local health care community with an estimate of the additional resources necessary to address health care needs in the Libby area during the next 10–20 years.

In cooperation with ATSDR, the U.S. Environmental Protection Agency (EPA) and the National Institutes of Occupation Safety and Health (NIOSH) have completed a detailed and task-based exposure evaluation in the community of Libby (EPA, 2001). Results of the EPA/NIOSH environmental exposure investigation, coupled with medical screening results presented herein will assist in determination of the nature and extent of cleanup actions for the community of Libby.

BACKGROUND

Commercial vermiculite from Zonolite Mountain, located approximately 6 miles from the city of Libby, Montana, was mined and milled from 1924 through 1990. This operation included blast and drag-line ~~strip~~ mining for the ore, on-site dry milling of the raw material until 1974 and periodic wet milling until 1990. The milling process was known to have released significant quantities of asbestos into the Libby airshed. Concentrated ore was then transported to a screening facility at the base of Zonolite Mountain where it was size-sorted and transported to processing facilities in Libby and nationwide. At the expanding facilities the ore concentrate was ~~expanded~~ Popped or 'exfoliated' by rapid heating. This process was known to further release asbestos fiber embedded in the mineral matrix of the ~~ore transporting it by truck to a sorting facility and to processing plants in downtown Libby, expanding the ore by heating, and shipping it by rail as a commercial product. A transfer facility was located at the base of the mountain, approximately 3 miles from Libby.~~ Two expansion ~~("popping")~~ facilities operated at different time periods in the city; these plants heated ore concentrate ~~vermiculite~~ to expand ~~(or "pop")~~ the vermiculite. ~~crystals~~

released significant amounts of asbestos into the Libby airshed.

To date the toxicity of vermiculite is not completely understood. However, it is thought that the toxic effects associated with vermiculite exposure are related to the presence of asbestoform minerals present in vermiculite ore and released during mining and processing operations. Evidence shows that ore taken from the Libby mining operation has been contaminated with asbestoform minerals, including primarily winchite, and richterite but also including other asbestiforms such as tremolite, actinolite, and others [DOI, 1928, USGS 2001, Atkinson et al.1982 and Lockey 1984]. Asbestos minerals fall into two groups or classes—serpentine and amphibole. Serpentine asbestos contains the mineral chrysotile. Minerals in the amphibole class are actinolite, anthophyllite, amosite, crocidolite, and tremolite. For the remainder of this report (unless otherwise specified), the term "asbestos" or "asbestos-related" refers generally to amphibole asbestoform minerals associated with vermiculite mined near Libby, Montana.

This is not about vermiculite but rather asbestos from the Libby air.

Inhalation of asbestos fibers from asbestoform minerals suspended in air can result in a number of adverse health effects including pleural changes, asbestosis, mesothelioma, and lung cancer (Selikoff and Chrug, 1965; Albelda et al., 1982; Kilburn et al., 1985; Anderson, et al., 1976). The risk of developing any one of these diseases depends upon many factors including the chemistry and shape of the fiber, ~~type of fiber,~~ level of exposure, duration of exposure, the individual's physiological response to fiber exposure, and cigarette smoking history of the exposed individual. Changes in the lining of the pleura include plaques (circumscribed pleural thickening), diffuse pleural thickening, calcifications, and pleural effusions (accumulations of fluid in pleural space). The presence of pleural abnormalities on chest radiograph, associated with asbestos exposure, indicates an increased risk for mesothelioma and lung cancer. The risk for lung cancer is related to cumulative asbestos exposure and the type of fiber inhaled. In addition, cigarette smoking increases the risk for lung cancer among persons with asbestos exposure above the additive risk of either smoking or asbestos exposures alone. The prevalence of mesothelioma, a rare cancer of the mesothelial cells of the peritoneum or pleura, is strongly associated with asbestos exposure. However, mesothelioma has been seen after exposures to relatively low levels of asbestos for short time periods (Becklake 1976).

Another health effect related to asbestos exposure is abnormal ventilation which is measured by spirometry or lung function testing. The two types of abnormal ventilation identified by spirometry are called restrictive and obstructive patterns. The obstructive pattern results from decreases in expiratory flow rates and is indicative of asthma chronic bronchitis, and/or emphysema. The restrictive pattern results from decreases in pulmonary air volumes associated with parenchymal disease (as in sarcoidosis or pneumoconiosis) or extraparenchymal disease (as with neuromuscular or chest-wall disorders). Patients with asbestos-related pulmonary impairment typically demonstrate restrictive abnormalities on spirometry testing.

Previous studies by the National Institute of Occupational Safety and Health (NIOSH) [Amandus et al. 1987a, 1987b, 1987c] and McGill University (MacDonald et al., 1986) ~~[Amandus et al. 1987a, 1987b, 1987c]~~ found that former workers of the mine in Libby had substantial occupational exposure to asbestos. These studies ~~also~~ both documented significantly increased rates of pulmonary abnormalities and disease (asbestosis and lung cancer) among former workers ~~[McDonald et al. 1986]~~. In addition to former workers at the mine, cases of asbestos-related pulmonary impairment have been reported among household contacts of former mine workers. Asbestos-related disease also has reportedly occurred among other residents of the community with no known direct connection with the mining operation. This is extremely unusual and suggests that asbestos exposure occurred in Libby from alternative or non-occupational exposure pathways. Some potentially important alternative pathways for past asbestos exposure include elevated concentrations of asbestos in ambient air [EPA 1982], and recreational exposures from children playing in piles of vermiculite. Currently, some potentially important pathways of exposure include vermiculite placed in walls and attics as thermal insulation, vermiculite or ore used as road bed material, ore used as ornamental landscaping, and vermiculite or concentrate as a soil amendment or aggregate in driveways and gardens.

This report outlines the self-reported exposure pathways and health outcomes for 6,149 persons participating in an on-site medical testing program from July through November, 2000, in Libby, Montana. The main objectives of the data analysis were (1) to identify and quantify possible asbestos-related health outcomes among participants and (2) to examine any association between these outcomes and the particpants' exposure histories.

METHODS

Participants

Persons were eligible for participation in the medical testing program if they were former workers of W.R. Grace/Zonolite Company (hereafter WRG), secondary contractors of WRG, household contacts of former WRG workers, or had resided, worked, attended school, or participated in activities in the Libby area for 6 months or more before December 31, 1990. The medical testing program consisted of a standard questionnaire, three-view chest radiographs and simple spirometry testing. Prior to the start of the medical testing program, there had been national-level press coverage of the vermiculite problem in Libby, thus community awareness was high and residents were very motivated to participate. Participants were identified from telephone directories and additionally through paid newspaper, radio and television advertisements as well as through word of mouth and medical referrals. A toll-free telephone line was established for interested persons to obtain information about the program and for screening participants to determine eligibility. Telephone screening to determine eligibility began in April 2000, with on-site medical testing conducted from July through November, 2000.

After informed consent was obtained, an in-person interview using a computer-assisted questionnaire was administered to obtain health-related information, including demographic characteristics such as age and sex, residential history, occupational history, recreational activities and other potential pathways related to asbestos exposures, cigarette smoking status, medical history, and self-reported symptoms and illnesses. Covariates potentially related to both exposures and outcomes included age, sex, body mass index (BMI), cigarette smoking status, length of residence in the Libby area, concern with neighborhood environment and self-reported pulmonary disease chest injury or chest surgery.

Chest radiographs were offered to participants 18 years of age or older and included posterior-anterior (P-A), right anterior-oblique, and left anterior-oblique views. For safety purposes, women of childbearing age were informed that they should postpone receiving a chest radiograph if they were pregnant. The test facility, equipment and procedures used to obtain the chest radiographs were purchased by U.S. EPA and complied with guidelines developed by NIOSH (Sargent 1982). The radiologist on site assessed the consistency and quality of each chest radiograph taken and provided a routine radiologic interpretation, which included recording asbestos-related changes on a summary report form. If findings on a chest radiograph suggested the need for immediate medical attention, the on-site radiologist completed a referral form, and the participant was counseled and directed to an appropriate source of medical care.

In addition to evaluation and interpretation by the on-site radiologist, participants' chest radiographs were evaluated by three certified B-readers, physicians certified by NIOSH as qualified to interpret chest radiographs for environmental dust-related diseases. For this report, we defined a case of pleural abnormality as (1) pleural abnormalities identified by at least two of three B-readers using a combination of oblique and P-A views of the chest radiograph, and (2) interstititial abnormalities identified by at least two of the three B-readers using the P-A view of the chest radiograph. Although the typical radiologic evaluation under the International Labor Office (ILO) classification uses only the P-A view (ILO 1980), use of both the P-A and oblique views increases the ability to detect abnormalities. To facilitate comparisons with other studies, pleural abnormalities found only in the P-A views were also noted. Interstitial disease, in comparison to pleural disease, is best detected using the P-A view. Consequently, only the P-A view was used to report interstitial disease.

In addition to outcomes based on chest radiographs, other outcomes were considered for analysis including: self-reported health conditions associated with asbestos; malignant outcomes associated with asbestos exposure (such as lung cancer and mesothelioma); and restrictive abnormalities based on pulmonary function tests. Pulmonary function testing or spirometry testing was offered to all participants. These tests followed the American Thoracic Society's guidelines and were performed by a qualified technician and interpreted by an on-site pulmonogist. The spirometric tests recorded (a) the forced expiratory volume in 1 second (FEV1); (b) the volume that can be expired, regardless of time, after a maximal inhalation, typically called the forced vital capacity (FVC); and (c) their calculated ratio (FEV1/FVC). Height and weight were measured for comparison with normative population data on the basis of the participant's age, height, and sex. Moderate-to-severe restrictive changes were defined as FVC that is less than 70% of predicted value.

Exposure Characterization

To describe potential pathways of exposure to asbestos or vermiculite, participants were asked about work histories including having worked for WRG or as a contractor for WRG, having been exposed to dust at non-WRG jobs, having mixed, cut or sprayed asbestos, or having had other occupational exposure to asbestos. Other questions sought information on household contact with WRG workers, having asbestos products in the home, use of vermiculite in gardening or insulation, and exposures through recreational activities such as playing in vermiculite piles and playing in the ballfield near the expansion plant or playing along Rainey Creek Road. Participants were also asked if they had 'popped' vermiculite at home or if they had any other contact with vermiculite.

RESULTS

Description of the Participants

A total of 6,149 current and former residents of Libby and surrounding areas participated. This represents a substantial proportion (60.5%) of the 10,161 persons in the Libby division of Lincoln County (U.S. Bureau of the Census 2000). Of these, 5,590 (90.9%) were age 18 and older and therefore eligible for chest radiographs. A breakdown of the population by sex and age group is displayed in Table 1.

Table 1. Medical Testing Participants by Sex and Age Group

Sex	Age Group	Number	%
All	0-17	559	9.01
	18-44	2052	33.4
	45-64	2531	41.2
	65 or greater	1007	16.4
Male	0-17	273	4.4
	18-44	972	15.8
	45-64	1263	20.5
	65 or greater	499	8.1
	All Ages	3007	48.9
Female	0-17	286	4.7
	18-44	1080	17.6
	45-64	1268	20.6
	65 or greater	508	8.3
	All Ages	3142	51.1

The participants were nearly evenly divided by sex, 49% male and 51% female, with a similar sex distribution in each age group. The majority of participants were age 18-65 years (75%), and 44% were in the 45-64 age group. Of those participants who had chest radiographs, 37% were age 18-44, 45% were age 45-64 and 18% were 65 or older.

A breakdown of the population by sex and other key factors or covariates is displayed in Table 2. Fifty-four percent (54%) of males and 45% of females were former or current cigarette smokers. Approximately half of the participants had never smoked. Of those, 85% were age 18 or older. Females were slightly more likely to be current smokers (21% vs. 18%).

Males and females had similar distributions for years of residence in the Libby area.. Roughly 74% of the participants lived in the Libby area for 15 years or more. Of the 1,598 participants who lived in the Libby area for less than 15 years, 377 (24%) were age 17 or younger.

~~Many of the participants were overweight.~~ A BMI of 25 to 29.9 is considered overweight and a BMI of 30 or above is considered obese; 67% of participants had a body mass index 25 or higher. Males were more likely than females to have a BMI over 25 (72% vs. 62%), but females were slightly more likely to be obese (33% vs. 31%).

Table 2. Key risk factors by sex

Variable	Level	Male	Female

Smoking History	Never	1391	1732
	(%)	(46.3%)	(55.1%)
	Ex-Smoker	1064	749
	(%)	(35.4%)	(23.9%)
	Current	551	660
	(%)	(18.3%)	(21.0%)
Years Lived in Libby	0-14	787	811
	(%)	(26.3%)	(25.9%)
	15-22	701	822
	(%)	(23.4%)	(26.3%)
	23-34	740	761
	(%)	(24.7%)	(24.3%)
	34+	763	738
	(%)	(25.5%)	(23.6%)
Body Mass Index	0-18	82	125
	(%)	(2.8%)	(4.0%)
	19-24	742	1066
	(%)	(24.9%)	(34.3%)
	25-29	1227	888
	(%)	(41.2%)	(28.6%)
	30+	929	1028
	(%)	(31.2%)	(33.1%)

Exposure Characterization

The eighteen exposure pathways that were used in the analyses are listed in Table 3. These include a number of occupational, recreational, household and other potential exposures reported by the participants. Using these pathways, an exposure profile was created for each participant for the different analyses. For some analyses, exposure variables were grouped according to broad classifications such as occupational, recreational, household or miscellaneous exposure. The multivariate analyses focused on individual exposures controlling for all other exposures. Participants may have had one, several, or none of these exposures.

Table 3. Exposure Variables Used in the Analysis

Exposure Pathway	Abbreviation for Graphs
Ever work for WR Grace/Zonolite	Workwr
Secondary contractor work	Work2nd
Dust exposure at non WR Grace jobs	Workdust
Vermiculite exposure at non WR Grace jobs	Workvgrm
Worked in job mixing, cutting or spraying asbestos	Workoth10
Worked at any job exposed to asbestos	Workoth12
Asbestos exposure in the military	Milexp
Lived with WR Grace/Zonolite workers	HHWR
Vermiculite insulation in Lincoln County homes	Vermins
Asbestos products in Lincoln County homes	Asb
Used Vermiculite for gardening	Vermgard
Used Vermiculite around the home	Vermuse
Handled Vermiculite insulation	Vermhand
Recreational activities along Rainey Creek	Recre
Played at ballfield near expansion plant	Playball
Played in Vermiculite piles	Vermplay
Popped Vermiculite	Vermpop
Other contact with Vermiculite	Vermcont

Figures 1-3 compare the proportion of male and female participants reporting various exposure pathways.

Figure 1: Occupational Exposure to Asbestos or Vermiculite

Proportions by Male and Female

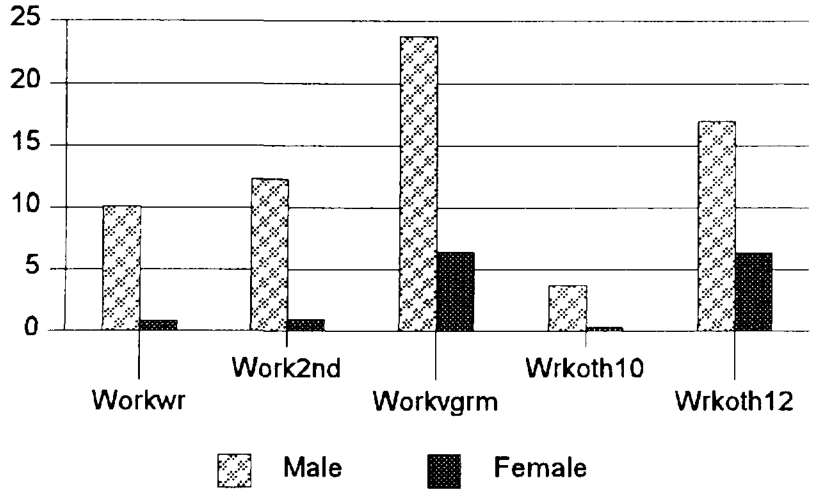


Figure 1 shows that males were much more likely than females to have reported occupational exposures. Among those who reported having worked at WRG, 303 (92%) were male and 25 (8%) were female. Overall, 10% of males reported having worked at WRG and 12% reported having worked as a secondary contractor there. Twenty-four percent (24%) of males reported Vermiculite exposure at non WRG jobs. Two percent (2%) of respondents reported mixing, cutting, or spraying asbestos at non-WRG jobs, and 12% reported being exposed to asbestos at non-WRG jobs. Of those who reported having worked at WRG, 57% were age 45-65, 27% were age 65 and older, and 16% were age 18-45.

Figures 2 and 3 show that males were more likely than females to have engaged in non-occupational activities that exposed them to asbestos or vermiculite, though the differences were less pronounced compared to occupational exposures. The only notable exception was that females were more likely than males to have been a household contact of a WRG worker (60% vs. 40%).

Figure 3: Other Exposure to Asbestos or Vermiculite

Proportions by Male and Female

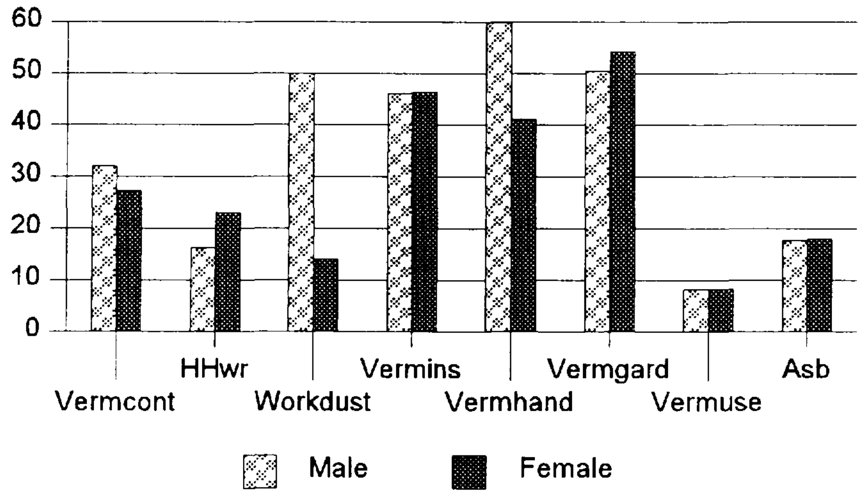
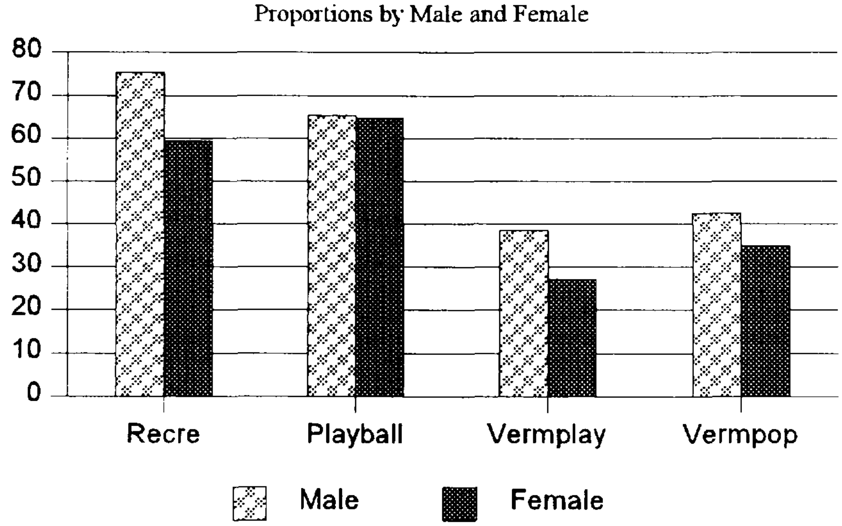


Figure 2: Recrecreational Exposure to Asbestos or Vermiculite

Proportions by Male and Female



Of the various exposure pathways, the most common was recreational activities along Rainey Creek Road (4115 {67%} reporting 'yes') and the least common was working with asbestos in a non WRG job (2%). Playing in the ballfields near the expansion plant was reported by 3991 participants (65%) and 2001 (32%) reported playing in Vermiculite piles.

Chest Radiograph Abnormalities - Crude Analysis

The tables in this section report crude, or unadjusted, prevalence rates of abnormalities for the exposure categories and other risk factors. The prevalence rates are simply the number of abnormalities occurring in persons in each exposure category. These crude proportions or prevalence rates did not take into account other important risk factors and are intended to be used for descriptive purposes. Because the prevalence of these abnormalities increases with age and may differ by other risk factors such as sex or BMI, adjustments for these variables were made in subsequent analyses presented later in this report.

Table 4 summarizes the number and proportion of participants having a possible asbestos-related interstitial or pleural abnormality that was identified on the chest radiograph by at least 2 b-readers. Results are presented by exposure pathway and radiographic view.

This table shows that using all views is more sensitive than either the P-A or oblique view alone for detecting pleural abnormalities. It also shows that the prevalence of pleural findings was considerably higher than for interstitial findings: 994 (18%) participants (age 18 and older) had a pleural abnormality (all views) compared to only 1% who had an interstitial abnormality.

Table 4. Number and (percent) of Pleural and Interstitial ~~Findings~~ Abnormalities by View and Exposure Variable

Exposure Pathway	Pleural All Views	Pleural P-A View	Pleural Obl View	Interstitial P-AView

All	994 (17.8)	780 (14.0)	657 (11.8)	49 (0.9)
Ever work for WRG/Zonolite	159 (48.5)	137 (41.8)	119 (36.3)	14 (4.3)
Secondary contractor work	147 (36.8)	109 (27.3)	92 (23.1)	8 (2.0)
Dust exposure at non WRG jobs	436 (22.4)	327 (16.8)	298 (15.3)	20 (1.0)
Vermiculite exposure at non WRG jobs	215 (23.6)	166 (18.2)	135 (14.8)	8 (0.9)
Non WRG job working w/ asbestos	38 (31.4)	31 (25.6)	22 (18.2)	2 (1.7)
Worked at any job exposed to asbestos	173 (24.7)	133 (19.0)	113 (16.1)	6 (0.9)
Asbestos exposure in the military	63 (41.5)	52 (34.2)	40 (26.3)	1 (0.7)
Lived with WRG/Zonolite workers	303 (25.5)	255 (21.4)	207 (17.4)	16 (1.3)
Vermiculite insulation in homes	509 (21.2)	409 (17.1)	332 (13.8)	26 (1.1)
Asbestos products in homes	186 (20.1)	136 (14.7)	121 (13.1)	8 (0.9)
Used Vermiculite for gardening	602 (20.3)	472 (16.0)	396 (13.4)	27 (0.9)
Used Vermiculite around the home	92 (19.8)	75 (16.1)	65 (14.0)	0 (0.0)
Handled Vermiculite insulation				
Sometimes	481 (20.9)	383 (16.7)	328 (14.3)	22 (1.0)
Frequently	165 (26.6)	133 (21.5)	105 (16.9)	9 (1.5)
Recreational activities along Rainey Creek Road				
Sometimes	455 (17.4)	347 (13.3)	317 (12.1)	18 (0.7)
Frequently	265 (21.7)	211 (17.3)	174 (14.2)	15 (1.2)
Played at ballfield near expansion plant				
Sometimes	248 (14.8)	184 (11.0)	172 (10.3)	8 (0.5)
Frequently	364 (18.8)	294 (15.2)	239 (12.3)	16 (0.8)
Played in Vermiculite piles				
Sometimes	213 (18.7)	165 (14.5)	146 (12.8)	8 (0.7)
Frequently	195 (26.0)	165 (22.0)	133 (17.7)	5 (0.7)
Popped Vermiculite				
Sometimes	392 (21.7)	317 (17.5)	268 (14.8)	12 (0.7)
Frequently	119 (25.4)	99 (21.2)	84 (18.0)	9 (1.9)
Other contact with Vermiculite				
Sometimes	279 (19.4)	215 (15.0)	195 (13.6)	11 (0.8)
Frequently	59 (24.8)	56 (23.5)	35 (14.7)	5 (2.1)

The table also shows the crude proportions of abnormalities for the various exposure pathways. These prevalence rates do not account for the possible influence of confounding variables or multiple exposures, and so cannot be used to establish a causal relationship. Nevertheless, they can be useful for identifying potentially important risk factors and to guide further environmental investigations. The exposure pathway with the highest unadjusted rate for pleural abnormalities was former WRG workers, with 159 (49%) having pleural abnormalities.

Crude odds ratios for pleural abnormalities (all views) and exposure pathways are displayed in Table 5. The odds ratio is the odds of finding a pleural abnormality for participants with a given exposure compared to those without the exposure. For example, an odds ratio of 2 would mean that the odds (risk) of observing an abnormality for a participant with an exposure is 2 times as great as that of a participant without the exposure. As in the previous table, these odds ratios do not account for confounding variables or the possibility that participants may have had multiple exposures. Such factors are accounted for in the multivariate analysis to follow.

Table 5. Crude Odds Ratios for Pleural Findings by Exposure Variable [add column with 'N']

Exposure Pathway	OR (95% CI)
Ever work for WR Grace/Zonolite	5.0 (4.0-6.3)
Secondary contractor work	3.0 (2.4-3.7)
Dust exposure at non WR Grace jobs	1.6 (1.4-1.8)
Vermiculite exposure at non WR Grace jobs	1.6 (1.3-1.8)
Worked in job mixing, cutting or spraying asbestos	2.2 (1.5-3.2)
Worked at any job exposed to asbestos	1.6 (1.3-2.0)
Asbestos exposure in the military	1.4 (1.0-1.9)
Lived with WR Grace/Zonolite workers	1.8 (1.6-2.1)
Vermiculite insulation in Lincoln County homes	1.5 (1.3-1.7)
Asbestos products in Lincoln County homes	1.2 (1.0-1.4)
Used Vermiculite for gardening	1.4 (1.3-1.7)
Used Vermiculite around the home	1.2 (0.9-1.5)
Handled Vermiculite insulation	
Sometimes	1.8 (1.5-2.1)
Frequently	2.4 (2.0-3.0)
Recreational activities along Rainey Creek	
Sometimes	1.1 (0.9-1.3)
Frequently	1.5 (1.2-1.8)

Played at ballfield near expansion plant	
Sometimes	0.7 (0.6-0.9)
Frequently	1.0 (0.8-1.1)
Played in Vermiculite piles	
Sometimes	1.2 (1.0-1.4)
Frequently	1.8 (1.5-2.2)
Popped Vermiculite	
Sometimes	1.6 (1.4-1.9)
Frequently	2.0 (1.6-2.5)
Other contact with Vermiculite	
Sometimes	1.6 (1.2-2.2)
Frequently	1.4 (1.0-1.9)

*Exposure pathway of interest compared with those without that specific exposure. Participants may have had multiple pathways of exposure.

Crude proportions and odds ratios for pleural abnormalities (all views) for other important risk factors are displayed in Tables 6-11. Table 6. shows proportions and odds ratios for pleural abnormalities by sex. Males had a significantly higher rate of abnormalities (27%) in comparison to female participants (9%). Males were more likely to report occupational exposures and were more likely to report frequent recreational activities that involved vermiculite exposure.

Table 6. Crude Rates and Odds Ratios by Sex

		Pleural Findings - All Views				
Sex	n	Normal	Abnormal	% Abnormal	Odds Ratio	95% CI
Female	2856	2602	254	8.9	1.0	0
Male	2734	1994	740	27.1	3.8	3.3 - 4.4

Table 7 shows proportions and odds ratios for pleural abnormalities by age. The odds of observing pleural abnormalities increases with age, which is related to latency and length of exposure. Rates increase from 5% in young adults age 18-44, to 20% for participants age 44-65, to 38% for participants age 65 years and older.

Table 7. Crude Proportions and Odds Ratios by Age

		Pleural Findings - All Views				
Agegrp	n	Normal	Abnormal	% Abnormal	Odds Ratio	95% CI
18-44 Years	2052	1949	103	5.0	1.0	0
45-64 Years	2531	2021	510	20.2	4.8	3.8 - 6.0

65+ Years	1007	626	381	37.8	11.5	9.1 - 14.6

Table 8 shows pleural findings for those participants age 18-35. The Libby community expressed a particular interest in an assessment of health risks for the younger participants so additional analyses were conducted on this age group.

Table 8. Pleural Findings Among Participants Age 18-35

		Pleural Findings - All Views		
Sex	n	Normal	Abnormal	% Abnormal
All	897	881	16	1.8
Male	418	403	15	3.6
Female	479	478	1	0.2

Of the 897 participants age 18 to 35, 16 were observed to have a pleural abnormality. Of these 16 participants, 1 was age 20, 4 were age 25-29, and the remaining 11 were age 30-35. The abnormality rates were 0.3% for participants 18-24 years old, 0.9% for participants 18-29 years old and 1.8% for participants 18-35 years old. A further analysis of the 16 participants with pleural abnormalities showed that they were more likely to be male, to be overweight (to be in the highest quartile for BMI), and to have reported frequent recreational activity such as playing in the vermiculite piles or "popping" vermiculite. Multivariate analysis of participants age 18-35 identified popping vermiculite, being male, and having a high BMI to be statistically associated with finding a pleural abnormality.

Table 9 shows crude proportions and odds ratios for pleural abnormalities (all views) by cigarette smoking history. Current and former smokers were more likely to have findings of pleural abnormalities than those who never smoked. This finding may be related to an association between cigarette smoking and exposure risk factors such as occupational exposure to asbestos.

Table 9. Crude Rates and Odds Ratios by Cigarette smoking History

		Pleural Findings - All Views				
Smoke	n	Normal	Abnormal	% Abnormal	Odds Ratio	95% CI
Never	2644	2328	316	12.0	1.0	0
Ex-Smoker	1764	1281	503	28.2	2.9	2.5 - 3.4
Current	1160	986	174	15.0	1.3	1.1 - 1.6

Table 10. shows proportions and odds ratios for pleural abnormalities by body mass index. Those with a high body mass index were more likely to have a finding of pleural abnormalities and the risk for pleural abnormalities increases with increasing quartiles of BMI.

Table 10. Crude Rates and Odds Ratios by Body Mass Index

		Pleural Findings - All Views				
BMI	n	Normal	Abnormal	% Abnormal	Odds Ratio	95% CI
1st Quartile	1170	1069	101	8.6	1.0	0
2nd Quartile	1252	1073	179	14.3	1.8	1.4 - 2.3
3rd Quartile	1485	1203	282	19.0	2.5	2.0 - 3.2
4th Quartile	1627	1208	419	25.8	3.7	2.9 - 4.6

Table 11. shows crude proportions and odds ratios for pleural abnormalities by length of residency in the Libby area. Those who lived in the Libby area for 35 years or longer were more likely to have pleural abnormalities than those who did not (33% vs. 12%).

Table 11. Crude Rates and Odds Ratios by Length of Residency

		Pleural Findings - All Views				
ResDur	n	Normal	Abnormal	% Abnormal	Odds Ratio	95% CI
0-14 Years	1221	1080	141	11.6	1.0	0
15-22 Years	1342	1209	133	9.9	0.8	0.7 - 1.1
23-34 Years	1501	1277	224	14.9	1.3	1.1 - 1.7
35+ Years	1501	1008	493	32.8	3.8	3.1 - 4.6

Multivariate Analysis - Adjusted Rates

The crude and univariate analyses considered thus far do not account for the possibility that individual associations can become weaker or stronger in the presence of other variables (known as interaction), nor do they account for the possibility that factors may confound each other. The multivariate analysis overcomes these limitations and is a useful tool for assessing the effect of several factors acting together and their association with an outcome.

Multivariate logistic regression was used to assess the association between pleural abnormalities and 17 exposure pathways, while adjusting for age, sex, BMI, cigarette smoking status, years lived in the Libby area, neighborhood environmental concern level, and pulmonary disease or pulmonary surgery or injury. The final model is displayed in Table 12.

Table 12. Results of Multivariate Logistic Regression Analysis [Add column with 'N' for each variate]

Variable	Level	Beta	P-Value	Odds Ratio
Intercept		-12.14	<0.01	
Workwr	Yes	2.05	<0.01	
Work ind	Yes	0.32	0.02	1.35 (1.04-1.83)
HHWR	Yes	1.20	<0.01	
Vermpop	Sometimes	0.30	<0.01	1.35 (1.10-1.65)
	Frequently	0.26	0.14	1.29 (0.92-1.81)
Playball	Sometimes	-0.09	0.47	0.92 (0.73-1.16)
	Frequently	0.21	0.09	1.23 (0.97-1.56)
Vermplay	Sometimes	0.50	<0.01	1.65 (1.29-2.11)
	Frequently	0.57	<0.01	1.76 (1.31-2.36)
Subsex	Male	1.60	<0.01	
Resdur	14-22 Years	0.12	0.47	1.12 (0.82-1.55)
	22-34 Years	0.21	0.16	1.23 (0.92-1.64)
	35+ Years	0.72	<0.01	2.05 (1.56-2.69)
Age		0.43	<0.01	
BMI	2nd Quartile	0.32	0.06	1.37 (0.99-1.90)
	3rd Quartile	0.44	0.01	1.55 (1.13-2.12)
	4th Quartile	1.17	<0.01	3.21 (2.37-4.36)
Smoke	Ex-Smoker	0.35	<0.01	1.42 (1.16-1.74)
	Current	0.35	0.01	1.42 (1.10-1.85)
Age*Workwr	Yes	-0.02	0.04	
HHWR*Subsex	Yes*Male	-0.63	<0.01	
Age*ln(Age)		-0.07	0.01	

Final Model Fit: Hosmer-Lemeshow Goodness-of-Fit Test, Chi-Square = 4.33, DF = 8, Pr > Chi-Square = 0.83

The regression model can be used to make comparisons between various groups and to assess the relative importance of various exposure pathways and covariates in predicting pleural abnormalities.

The model shows that the following factors are associated with pleural abnormalities: having been a WRG worker or a secondary contractor at WRG; having been a household contact of a WRG worker; having frequently popped vermiculite, played in vermiculite piles or played at the ballfields near the expansion plants; being male; being older; having lived in the Libby area for a longer period of time; having smoked cigarettes; and having a high BMI.

The model also shows that several of the variables interact with each other. For example, the odds of having a pleural abnormality among former WRG workers differs with age. As age increases, the odds of having a pleural abnormality increases, but not as quickly for former W.R. Grace workers as for non-W.R. Grace workers. The model also shows that odds of having a pleural abnormality among household contacts of former WRG workers is higher for females than for males.

The risk factors that produced the largest increase in the odds of finding pleural abnormalities were: being a former WRG worker, being male, and being a female household contact of a former WRG worker. The model shows that the estimated odds of finding a pleural abnormality is 7.7 times higher for a former WRG worker compared to a non-worker of the same age, adjusting for all of the other variables in the model (i.e., assuming that the participants being compared are alike with respect to age, sex, BMI, residential history, cigarette smoking status, and other risk factors considered in the model). The model shows that the estimated odds of finding a pleural abnormality is 4.97 times as high for males than it is for females after adjusting for other variables in the model. The estimated odds of finding a pleural abnormality is 3.3 times higher for females who were household contacts of former WRG workers compared to females who were not. The corresponding increased odds for males is 2.7. The model also shows that as age increases the odds of finding a pleural abnormality increase, though the relationship is non-linear. For example, the estimated odds of finding a pleural abnormality for a 30 year old is 3.65 times higher than for a 20 year old. However, the odds reduce to 2.08 when comparing a 60 year old to a 50 year old. Among the non-occupational or household contact exposure pathways, playing in the vermiculite piles frequently was most associated with and increased odds of finding pleural abnormalities. Those who played in the piles frequently had an estimated odds of pleural abnormalities 1.76 times higher than those who never played in the piles. The model predicts that those participants with multiple exposures have increased risk of abnormal pleural findings than those with only a subset of the exposures. The majority of these participants reported multiple, rather than single exposure pathways.

The distribution of exposure pathways is displayed in Table 13. Only 2.6% of participants had no apparent exposure. Over 40% of the participants reported six or more exposure pathways.

Table 13. Distribution of Multiple Exposure Pathways for All Participants

Number of Pathways	Frequency	Percent
0	159	2.6
1	412	6.7
2	703	11.4
3	797	13.0
4	801	13.0
5	817	13.3
6	709	11.5
7	644	10.5
8	488	7.9
9	280	4.6
10	179	2.9
11	104	1.7
12	38	0.6
13	14	0.2
14	3	0.1
15	0	0.0
16	1	0.0

The prevalence rates for pleural and interstitial abnormalities among participants with multiple exposures compared to those with no apparent exposures is displayed in Table 14.

Exposure Not a dose ?

Table 14. ~~Dose-Response~~ Relationship ~~- Background Rate~~

Exposure Classification	n	Pleural Findings - All Views		Interstitial Findings- PA View	
		Normal	Abnormal	Normal	Abnormal
0 Exposure Pathways	122	116	6	121	1
(No Apparent Exposure)		(95%)	(5%)	(99%)	(1%)
1-3 Exposure Pathways	1569	1394	175	1559	10
		(89%)	(11%)	(99%)	(1%)

4-5 Exposure Pathways	1488	1262	226	1471	17
		(85%)	(15%)	(99%)	(1%)
6+ Exposure Pathways	2411	1824	587	2390	21
		(76%)	(24%)	(99%)	(1%)

This table shows that 24% of persons reporting six or more exposure pathways (43% of participants with chest radiographs) had pleural abnormalities compared to only 5% in the no apparent exposure group. Of the interstitial findings in these groups, 1% occurred in the all exposure pathway groupings.

need operational definition of Rest. Abnormal

Pulmonary Function Testing

Table 14 summarizes restrictive abnormalities identified in the pulmonary function tests, by exposure pathway for those 18 years and older. This does not include participants who had significant obstructive lung changes, for whom restrictive changes could not be evaluated. Participants who reported they were former workers at WRG had the highest percentage of restrictive abnormalities of all exposure pathways. As with the interstitial changes seen on the chest radiographs, the number of participants with moderate-to-severe restrictive function was much lower than the number of participants with pleural abnormalities. There were no restrictive changes seen in participants less than 18 years of age.

20 ?

A multivariate logistic regression model showed that the following factors were associated with restrictive abnormalities: being a former WRG worker or having worked with vermiculite at a non-WRG job, having had chest surgery, being older, having a high BMI, and being a past or current smoker.

The risk factor that produced the largest increase in the odds of having a restrictive abnormality was being a current smoker. The estimated odds of a restrictive abnormality was 3.15 (1.4-7.0) times higher for a current smoker than that of a participant who never smoked. The estimated odds ratios for the other factors in the model were: 3.0 (1.6-5.8) for those who reported having had chest surgery, 2.8 (1.2-6.7) for those in the highest BMI quartile, 2.4 (1.2-4.8) for former WRG workers, and 2.0 (1.1-3.6) for non-WRG workers exposed to vermiculite.

The model also shows that as age increases the odds of finding a restrictive abnormality increase. A 10-year increase in age results in an estimated increase of 10.8 for the odds of restrictive abnormality.

Table 14. Restrictive Abnormalities in Pulmonary Function, by Exposure Group

Exposure Pathway	Moderate-to-Severe Restrictive Abnormalities (less than 70% of predicted values)		
	Normal	Abnormal	% Abnormal
Ever work for WRG/Zonolite	214	13	5.7
Secondary contractor work	259	6	2.3
Dust exposure at non WRG jobs	1325	28	2.1
Vermiculite exposure at non WRG jobs	592	20	3.3
Non WRG job working w/ asbestos	81	1	1.2
Worked at any job exposed to asbestos	486	7	1.4
Asbestos exposure in the military	95	1	1.0
Lived with WRG/Zonolite workers	796	24	2.9
Vermiculite insulation in homes	1639	39	2.3
Asbestos products in homes	611	19	3.0
Used Vermiculite for gardening	2045	48	2.3
Used Vermiculite around the home	324	4	1.2
Handled Vermiculite insulation			
Sometimes	1584	32	2.0
Frequently	413	11	2.6
Recreational activities along Rainey Creek			
Sometimes	1842	36	1.9
Frequently	841	16	1.9
Played at ballfield near expansion plant			
Sometimes	1196	24	2.0
Frequently	1409	14	1.0
Played in Vermiculite piles			
Sometimes	828	9	1.1
Frequently	520	10	2.0
Popped Vermiculite			
Sometimes	1282	22	1.7
Frequently	320	7	2.1
Other contact with Vermiculite			
Sometimes	995	16	1.6
Frequently	150	6	3.9

Exclusive or inclusive?

Participant-Reported Symptoms and Illnesses

Table 15 shows background rates of self-reported symptoms and illnesses. The most commonly reported illness was chest illness (28.1%). The most commonly reported symptom was shortness of breath (35.6%).

Table 15. Background Self-Reported Symptoms and Illnesses

	Number	%
Ever Had Tuberculosis (6142)	58	0.94
Ever Hospitalized for Pneum/Plrsy (6138)	885	14.42
Congestive Heart Failure (6136)	336	5.48
Other Chest Illnesses (6148)	1733	28.19
Chest Injury Such as Broken Rib (6141)	1030	16.77
Ever Had Chest Surgery (6148)	359	5.84
Lung Disease or Condition (6148)	780	12.69
Arthritis, Scleroderma, Lupus (5560)	413	7.43
Ever had Cancer (6138)	522	8.50
Cough Phlegm in Past 2 Years (5598)	1183	21.13
Hoarse or Difficulty Swallowing (6148)	1261	20.51
Chest Pains Related to Breathing (6135)	1103	17.98
Lost More Than 15lbs in Last 6 Months (6143)	327	5.32
Ever Coughed Bloody Phlegm (6137)	979	15.95
Cough on Most Days (6143)	1423	23.16
Shortness of Breath (6136)	2187	35.6

CONCLUSIONS

In the initial assessment of chest radiographs by the local radiologist or one B-reader, 30% of participants had a pleural abnormality and 7% had an interstitial abnormality. Those individuals were informed that they should have the finding reviewed by their private physician. The principal results of this report are based on findings by two out of three B-readers using three views of chest radiographs for pleural abnormalities and the P-A view for interstitial abnormalities.

Eighteen percent (18%) of the participants had pleural abnormalities which was reported by at least two out of three certified B-readers for P-A and oblique views combined. Interstitial abnormalities were seen in almost 1% of the participants. Although the ILO standard for screening for pleural abnormalities is based upon the P-A view, our analyses using the combination of P-A view and oblique views increased the sensitivity of this test. Pleural abnormalities identified by combined views (17.8%) was higher than those identified by P-A view alone (14%) and the oblique view alone (12%).

Pleural abnormalities

Pleural abnormalities varied by age, sex and BMI. Age is an important variable since it is related to both latency and length of exposure. Pleural abnormalities ranged from 5% in those 18 to 44 years of age to almost 40% in those 65 years of age and older. The youngest person with an abnormality was twenty years old, and this was the only person with an abnormality younger than 25 years of age. Only 5 people were identified with pleural abnormalities below the age of 30. The extremely low prevalence rate (0.3%) for pleural abnormalities among this youngest age group confirmed our initial decision to limit chest radiographs to those 18 years of age and older. Because of duration and latency considerations for these outcomes, we would not expect to see abnormalities in younger people.

Crude odds ratios of pleural abnormalities were almost four times higher among men than women. Men were more likely to be exposed to vermiculite through occupational or recreational contact. Not surprisingly, women were more likely than men to be exposed to vermiculite through household contact or gardening. In addition, prevalence of pleural abnormalities increased with increasing length of residence in the Libby area with an almost four-fold increased risk of pleural abnormalities among those with 35 or more years of residence compared with residents of 14 years or less. Residents who lived in the area a long time had more opportunities for exposures unique to the Libby area. Additionally they were more apt to be older than those who lived in the area for a short time.

Smoking tobacco products has not been identified, in previous studies, as a key pathological factor in the development of pleural abnormalities. However, in assessing pulmonary related changes, it is useful to control for this behavior in order be able to determine that pulmonary changes found associated with an environmental exposure could not be attributed to cigarette smoking.

BMI was also associated with pleural plaques in these analyses. While there is no known biological or pathological relationship between body mass and the development of pleural abnormalities, a heavier body mass index can make it more difficult to distinguish between pleural abnormalities and sub pleural or extrapleural fat (Sargent et al., 1984; Proto 1992). Therefore, this variable, along with age, cigarette smoking status and sex, were included in multivariate models assessing relationships between exposures to asbestos contaminated vermiculite and pleural abnormalities.

As expected, those who had worked for W.R. Grace had crude prevalence rates of 48% and were five times more likely to have pleural abnormalities than non-W.R. Grace workers. Family contacts of W.R. Grace or Zonolite workers were twice as likely to have pleural abnormalities as those who did not have this exposure. The crude odds ratios for all exposure categories, except playing ball near the expansion plant and using vermiculite around the home, were statistically, significantly elevated.

In multivariate analyses, the factors most strongly related to having pleural abnormalities were being a former WRG worker, being a household contact of a WRG worker and being male. Former WRG workers had almost 8 times the risk of pleural abnormalities compared with non-WRG workers . The risk of pleural abnormalities among household contacts of WRG workers varied by sex. Women household WRG contacts vs WRG non-contacts were at a higher risk of pleural abnormalities than male contacts vs. non-contacts. This may be due to gender differences in responsibilities for laundry and cleaning. These activities may lead to greater exposure to "take-home" dust. Additionally, women workers, who traditionally are found in more administrative or office occupations within industries, may have been exposed to less vermiculite on the job site than male workers and thus brought less vermiculite home. Men had almost 5 times the risk of pleural abnormalities compared with women. Other pathways of exposure associated with pleural abnormalities included playing in vermiculite piles and popping vermiculite.

Those who answered 'yes' to 6 or more exposure pathways had a prevalence rate of 24% for pleural abnormalities compared with 5% for those who had no apparent exposures. No directly comparable Montana or U.S. population studies are available to estimate the rate of pleural abnormalities among those in Libby with no work-related exposures in a similar population. Studies of differing groups within the United States believed to have no substantive work-related asbestos exposures have found the prevalence of pleural abnormalities ranging from 0.2% among blue-collar workers in North Carolina (Castellan 1985), to 0.9% among loggers in Washington and Oregon (Stilbolt 1991), to 1.8% among New Jersey residents (Anderson 1979), and 2.3% among patients at Veterans Administration hospitals in New Jersey (Miller JA 1996). The closest category to a 'non-exposed' group for these analyses was the category of 'no apparent exposure' which has a prevalence rate of 5% for pleural abnormalities. Although this is higher than those of control groups or the general population found in other studies, this category may have included exposures to vermiculite which we had not considered. Thus background prevalence rates for Libby may be as high as 2 to 25 times higher than the non-occupational U.S. population.

Interstitial abnormalities and restrictive changes in lung function

The proportion of interstitial abnormalities and moderate-to-severe restrictive changes on participants' spirometry tests is much smaller than pleural abnormalities. This finding is consistent with clinical reports by physicians in the Libby area that patients frequently present with pleural abnormalities. Interstitial abnormalities are well correlated with asbestos exposures, however these exposures are typically higher and more intense than those associated with the development of pleural abnormalities. ~~Exposure to asbestoform fibers in vermiculite may not be as intense as other types of asbestos exposures.~~ [not clear what you are trying to say... intensity of vermiculite fiber exposure is a function of frequency and duration which in turn are functions of source concentration and individual behavior.]

The strongest risk factor for restrictive changes in participants' spirometry testing for adults 18 years and older was current cigarette smoking, being a former WRG worker, having had chest surgery, being in the highest BMI quartile and age. Unfortunately, restrictive changes in lung function could not be evaluated in those participants who also had obstructive changes. No restrictive changes, as defined for these analyses, were seen in participants less than 18 years of age. However, latency and duration are important factors in the development of these changes and not enough time or duration of exposure may have occurred for changes to have occured in younger people.

Symptoms and illnesses

Perhaps not unexpectedly, the most commonly reported health problem was chest illness and the most commonly reported symptom was shortness of breath. These results are difficult to interpret because we do not have comparison rates for these outcomes and self-reported illnesses and symptoms are subject to recall bias.

Members of the community also requested that ATSDR report the findings for self-reported "arthritis, lupus (SLE), or scleroderma." Seven percent of the participants reported these conditions. The question did not distinguish between arthritis resulting from physical degeneration of joints (osteoarthritis), arthritis resulting from an autoimmune pathology (such as rheumatoid arthritis), or other forms of arthritis. Thus, all respondents cannot be assumed to be suffering from an autoimmune pathology. Asbestosis has been associated with immunologic changes (hypergammaglobulinemia, anti-nuclear antibodies, and rheumatoid factor) (Mulherin 1993) and persons with asbestosis may be predisposed to the development of SLE, given the immunological changes seen in asbestosis. However at the present time, there is only limited information about the association between auto-immune diseases and asbestosis. Also at this time, we have no prevalence rates for illnesses such as lupus or scleroderma for the general population which could serve as a comparison group.

Limitations

Information obtained through systematic survey methods or medical testing programs can have many limitations. The medical testing program was conducted with the principal goal of providing a service to the community and assisting EPA with exposure pathway definition [PLEASE BE SURE TO INCLUDE A STATEMENT TO THIS EFFECT]. The information will be useful for health care planning needs in the community, defining the scope of future environmental investigations, and understanding the ~~scope and~~ natural history of ~~the~~ asbestos-related illnesses which can assist local health care providers. A perspective on the magnitude of the public health problem in the Libby area can be summarized by examining the prevalence asbestos-related abnormalities among participants. ~~with but~~ However, judgements about the true extent of these abnormalities above expected values is difficult to determine. ~~d~~Direct comparisons of the occurrence of abnormalities above the expected value with the general population cannot be calculated ~~B~~because no control group was included. All studies involving volunteers are subject to selection bias. It is possible that those who volunteered for the program were more likely to have been previously diagnosed with an illness, were more likely to have experienced symptoms than a randomly selected population or were more likely to have had exposures and concerns about this. It is also possible that persons who thought they had little or no exposure chose not to participate. Nevertheless, this program screened over 6,000 persons in Libby and the surrounding area which represents a substantial proportion (61%) of the total population of the Libby area. Additionally, most of the findings in this report are on more objective outcomes such as findings from chest radiographs or spirometry measurements. Observer bias is limited by following established standards for interpretation of chest radiographs which require the use of B-readers trained in detection of occupational disease and agreement in two out of three B-readers. Findings on self-reported symptoms and illnesses must be interpreted with caution due to lack of comparison rates and the potential for recall bias.

SUMMARY

One of the principal objectives of the medical testing program was to identify illnesses experienced by participants exposed to asbestos in order to better inform local physicians. Pleural abnormalities were observed on the chest radiographs of almost 18% of participants in the medical testing program. Interstitial abnormalities were seen in 1% of participants. The risk of pleural abnormalities increased with increasing age and increasing length of residence in the Libby area. This suggests the possibility that abnormalities will continue to develop in this population as it ages.

A second objective was to better characterize pathways of exposure in this community and risk of illnesses. Such characterization may be useful for the purpose of defining or focusing environmental investigations in Libby and other areas of suspected human exposure to asbestos-contaminated vermiculite. The factors most strongly related to having pleural abnormalities were 1) having been a WRG worker, 2) having been a household contact of a WRG worker, and 3) being a male. The odds of finding a pleural abnormality was almost 8 times higher for former WRG workers compared to non-workers of the same age. The odds of finding a pleural abnormality was over 3 times higher for female household contacts of WRG workers compared females who did not report having this exposure. Men had almost 5 times the risk of pleural abnormalities as women.

Participants could have been exposed through several pathways. Crude odds ratios identified elevated risk from all but two of the exposure pathways investigated. This analysis found that 24% of participants with multiple exposures had abnormal pleural findings compared with 5% of participants with no apparent exposure.

Participants who reported they were former WRG workers had the highest percentage of restrictive changes of all exposure pathways as measured by pulmonary function testing. Being a current smoker was the strongest risk factor for having restrictive abnormalities. Other risk factors included being a former WRG worker, being a non-WRG worker exposed to vermiculite, having had chest surgery and being in the highest body mass index category.

This report summarizes the findings from the year 2000 medical testing program. Testing is continuing and as additional data are received, additional analyses will be conducted.

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